

methods of determining and allowing for these errors. In view of our present knowledge we now see that in establishing new stations better methods of exposure should be adopted, and such as are in fact very different from those that have hitherto been considered allowable. We must closely imitate the conditions prevailing at the average surface of the ground, that is to say, in the order of preference the exposure would be: (1) the pit gage; (2) the protected or the shielded gage near the ground; (3) several protected or shielded gages distributed over a flat roof; (4) the shielded gage on posts considerably elevated above slanting roofs. Moreover, in no case should a single gage be relied upon, but in all cases at least two similar gages at very different heights should be observed. From the records of these two gages we can compute the catch of the normal pit gage by the formula previously given.

As this formula is also applicable to the ordinary, and in fact to any form of gage, we furthermore see that an approximate correction, needed to reduce valuable past records to the normal gage, may now be determined, if these old gages are still being recorded, by at once establishing near them two or more similar gages at considerably different heights; from the records of all these gages for the next few years we may determine, at least approximately, a correction applicable to the past years of historical records. Finally, we are warned against attempting to draw from past records conclusions that are finer than the data will justify.

METEOROLOGY BY THE LABORATORY METHOD.

The November number of Popular Astronomy contains the following admirable article on the teaching of astronomy, which applies equally well to meteorology and is to be commended to all teachers and students.

If by the laboratory method is meant such observation and investigation of selected phenomena pertaining to any subject as shall yield to the student an abundance of essential facts—if it mean that from the many such related facts reasonable explanations of these phenomena may be expected from the student who thinks simply and logically—if it be a manner of so presenting a subject through its phenomena to the mind of a student that he may reach out toward conclusions of a general nature, to the principles and laws which pertain to that subject, as a direct sequence of his own observations and thought processes—if these be the aims of laboratory methods of teaching, then astronomy [and meteorology] may be thus taught, and demands such manner of presentation to the students of our secondary schools.

It is far from our purpose to pose as an instructor in pedagogy, or to enter upon any psychological discussion whatsoever. Yet it were pardonable, surely, to restate as a cardinal principle of educational work that mental growth results only from mind activity rightly directed. As the highest and best of the physical being demands that every muscle have its exercise and development, so the mind in its every capacity is to be exercised.

One stage in the development of the science of education was content to have the student memorize the words of the text regardless of any full comprehension of the thought expressed therein. It was a great step in advance when mastery of the thought of the author was made of prime importance, and the expression of that thought in the words of the student himself was encouraged or required. There remained a single step further, and with many a teacher it has yet to be taken in the full round of the science work, the *requirement of original thought from the student* as well as original expression of thought. To require of students in our secondary schools in study of any science nothing further than mastery of the thought of an author as expressed in the text book is neither the most complete nor the most profitable mental activity.

Allowing that we have in books veritable storehouses of the riches of ages of human experience, thoughts that are profound, language that is grand, thought expressions to whose depths and to whose heights we may scarcely hope to attain, expressions that may tax to the utmost our endeavors of a lifetime to rethink them, humble travelers as we are over well marked mental highways and byways—allowing all this, it is contended that the great mass of books put into the hands of our students are *not of this character*, and that the writers of modern text-books for secondary schools are few who seek to do other than to put before the student in the simplest, most elementary manner possible the facts of the subject treated. It is the facts themselves and the manner in which they are presented that is of prime importance. Any course in science that stops short of requiring original thinking by the student, thinking that is based upon facts that are leavened through and through with the results of personal observation and investigation must needs be comparatively barren of mental growth and vigor.

The logical result of such views is to regard the text-book in science as a reference book in simple compact form, furnishing what shall be needed to supplement the results of the student's own efforts in obser-

vation and thought—a reference book differing not a whit in purpose from the other reference books found in any well appointed laboratory save in its larger use and *that it is the student's own*.

Happily the day was soon past when the science student of our secondary schools was looked upon as a discoverer, as one who by his unaided efforts was to re-establish the laws, principles and theories of the subject he pursued and all this as a result of his own investigations. The story of Agassiz, his student and the fish, was made to teach preposterous lessons. In most of the sciences the limits of original investigation are well defined, the need and use of text and reference books well established in supplementing laboratory work. In astronomy [and meteorology], however, oldest of the sciences, science of the material universe, the student is too often expected to know nothing save what his author tells him, to cultivate no mental powers in its study save the taxing of an already overburdened memory; or, at most, his powers are taxed in making out what the author means in his text, and through the exercise of the imagination in picturing what the author describes as existing.

In any attempt to apply the laboratory method to the teaching of astronomy [and meteorology] there is the same necessity as in the other sciences that no time be wasted upon comparatively unimportant phenomena; that observation shall be so carefully directed as to readily acquire the desired facts; and that these results shall be so related as to make generalization possible. That there are difficulties in the way is true, but they may largely be included under these heads: (1) A failure on the part of many teachers to appreciate the fact that although many of the phenomena of astronomical [and meteorological] science require apparatus too expensive and too complicated to be available, and although many of the conclusions are reached through reasoning too abstract to be within the comprehension of the students to be instructed—there still is wide range for observation and inference fully within the comprehension of pupils of high school grade: (2) The text-books in astronomy [and meteorology], with but an exception or two, not only tell all the facts that the student can easily acquire for himself under direction as well as those beyond the range of his ability and opportunity, but, withal, their pages are crowded with ready made inferences from these facts, making it wholly unnecessary for the pupil to do any thinking himself beyond that involved in language interpretation. He may study astronomy and complete his course, but still has no more knowledge of the relation of his work to celestial phenomena than one who studies the bookkeeping of the high school instead of the actual business conditions it is supposed to exhibit. Science teaching in any grade of school work should surely not make memory and imagination a first consideration—observation and thinking a secondary matter.

When teachers of astronomy [and meteorology] shall be content no longer to instruct in this science upon a basis so radically different from that of the generally recognized laboratory sciences, and shall demand for laboratory reference text books that are filled with facts clearly and logically arranged, and having terse statements of the theories advanced therefrom, together with such descriptions and explanations as are beyond the ability of the average student for whom they are written, but which at the same time are free of all such matter as may properly be required of students as the result of their own observation and thinking—when teachers shall demand that guides and manuals for the study of astronomy [and meteorology] shall be furnished even as in physics and in chemistry, to the end that like principles of instruction and of laboratory procedure may be applied to all alike—then, and not till then, will publishers come to the relief of such teachers as already seek to secure in the teaching of astronomy [and meteorology] in secondary schools the fullness of its possibilities for mental development, even as with other sciences, in addition to its value otherwise so fully recognized.

THE RECURVING OF HURRICANE TRACKS IN THE NORTH ATLANTIC.

The Pilot Chart for November, published by the United States Hydrographic Office, gives a diagram showing the path followed by the centers of twenty-five tropical cyclonic storms in the North Atlantic Ocean during the ten years, 1890-99. Concerning these Mr. James Page, of that office, makes the following remarks:

Of these storms Nos. 2 and 9 each pursued a course trending between north and west, the former crossing Florida into the Gulf of Mexico, the latter disappearing over the mainland in the vicinity of Charleston. The course of Nos. 10 and 16 was in a northeasterly direction throughout, although it is probable that the complete history of these storms would show an earlier movement toward the northwest. The absence of observations, however, precludes in either case any attempt to represent this earlier portion of the track. No. 20 followed an almost due northerly course, keeping well under the coast, and No. 21, although the barometric depression accompanying the storm originated in the Gulf of Mexico, failed to attain full hurricane violence until reaching the position indicated.

The remaining tracks exhibit the usual features, the motion of the storm center in that portion of the track to the southward of 25° being directed toward a point between north and west, recurving at some point situated in general between 25° and 35°, and thence moving in a northeasterly direction. The position of this point of recurvature, or point of greatest westing, is given in the following table, in which the storms are arranged with reference to the date of recurving, without regard to the year:

Location of recurvature.

No.	Year.	Date.	Lat. N.	Long. W.	No.	Year.	Date.	Lat. N.	Long. W.
			°	'				°	'
7	1892	Aug. 19.....	28 30	67 30	17	1896	Sept. 22....	30 10	74 45
8	1893	Aug. 20.....	29 00	76 00	11	1894	Sept. 25....	25 15	82 12
3	1891	Aug. 23.....	36 00	64 00	18	1896	Sept. 28....	25 00	85 00
1	1890	Aug. 29.....	29 00	70 12	6	1891	Oct. 5.....	39 00	68 00
24	1899	Sept. 1.....	20 20	72 20	12	1894	Oct. 8.....	27 48	88 12
4	1891	Sept. 6.....	33 30	72 48	19	1896	Oct. 10.....	29 00	76 10
25	1899	Sept. 11.....	28 00	68 10	13	1894	Oct. 15.....	23 00	68 00
23	1898	Sept. 18.....	28 00	80 10	15	1895	Oct. 20.....	30 30	82 48
22	1898	Sept. 17.....	30 00	71 10	14	1894	Oct. 24.....	26 10	75 00
5	1891	Sept. 31...	32 30	64 36					

From this table it will be evident to the masters of vessels frequenting West Indian waters and exposed to the violence of West Indian hurricanes that to rely upon the assertion that the storms of a particular month recur within certain fixed and narrow limits of latitude may lead them into serious error at a most critical time. Thus the table shows that the hurricanes of September, instead of recurving between 27° and 29°, as formerly maintained, may in actual practice recur in any latitude from 20° 20' N. to 33° 30' N.; likewise those of October, instead of recurving in latitude 20° to 23° N., may continue their north-westerly course until the parallel of 30° is attained.

The mariner, like the forecaster, must always be on his guard against unexpected departures from normal types of storms and weather.

METEOROLOGY IN THE SCHOOLS.

Occasionally we are cheered by discovering an additional enthusiastic voluntary observer and teacher. The following letter from such an one breathes the right spirit and is worthy of record:

Two weeks ago we received notice from the Central Office that if we would contract to keep an unbroken series of observations, the Weather Bureau would establish a voluntary station at our college. Matters were soon arranged so that this would be possible, and the instrument shelter, rain gage, maximum and minimum thermometers, and record blanks have been received. As soon as the shelter can be put in place we shall begin regular observations. The college has purchased from Friez a barometer, barometer case, and sling psychrometer, all of which arrived on Saturday. The barometer is now hanging in the library, where it can be seen by all, and as soon as our classes in physical geography are well started there will be an intelligent interest taken in this instrument. Last night I explained its general principles to our librarian, who had never seen one before and had no idea of its construction or object.

I find that in order that this institution may be the general source of broad instruction that it ought to be, some one must take hold of those sciences in which I happen to have a general interest. I want this college to be an inspiration to the public school teachers in the State and their central authority for teaching and training in science. Our president feels an interest in meteorology and allied subjects, and we ought to be able to develop them here. I am introducing more laboratory work into this year's courses, but all our work must be of an elementary character as compared with that of the great universities.

If we science teachers at this place are to make the best of our opportunities to acquire an influence along educational lines, we must struggle against the natural tendency toward narrow sympathies; we must avoid too much specializing; we must give our pupils such instruction as will enable them to take an intelligent, because a practical, interest in all the important lines along which human knowledge is developing to-day. One of the reasons why we endeavored to secure a voluntary station at this college was the conviction that an every day acquaintance at first hand with the methods, instruments, and phenomena of meteorology will lead our students to acquire a truer and more sympathetic appreciation of the work of the U. S. Weather Bureau.

The daily map from our State center is displayed on a bulletin board in our front hallway, and in January the State section director is to give us a talk on practical meteorology.

REPLIES TO CORRESPONDENTS.

A correspondent sends the Editor a series of questions such as may possibly have occurred to others among our readers, and we therefore submit a portion of the reply for their information.

Violent thunderstorms visit the regions within 30 miles south of the St. Lawrence River during a great part of the summer. Three years ago, namely, in March, 1896, a "cyclone," as it is called by the country people, struck our place, throwing down barns, carrying a child several hundred yards, etc. From all I learn the tornado came from the west. In the face of all this, I want to know:

1. Is this region not supposed to be exempt from tornadoes?
2. Do not the mountainous features of the locality tend to break up the motion of the tornado?
3. Is the tornado more likely to strike places on an elevation than those in a valley or near a river?
4. Is an isolated house in the country safer with, or without, a lightning rod?
5. Is a stone house safer than a wooden one? The country people say that lightning kills the fruit of plum trees, singles out the fir tree for its shafts, but will never strike a beech, and that brilliant "northern lights" presage a storm. Is there any truth in these sayings?

We have no exact observational data relating precisely to all the matters involved in these questions, but it is allowable oftentimes to reason by analogy from what we know to that which would probably happen under analogous circumstances.

1. The northern limit of tornadoes has not yet been fixed by observations, but the data from Canadian, and especially United States Weather Bureau stations, would lead to the conclusion that along the southern bank of the St. Lawrence River one tornado is likely to occur within a region of 10,000 square miles, or 30 miles wide by 333 long, about once in ten years (see MONTHLY WEATHER REVIEW, Vol. XXV, p. 250). But the storm alluded to as having occurred in March, 1896, was probably not a tornado. The fact that the country people called it a "cyclone" has nothing whatever to do with its true character and simply shows that they do not understand the meaning of that word. A tornado is not only a violent wind, but one accompanied by a peculiar cloud formation. The under side of a cloud appears to suddenly extend downward to, or near to the earth, and this cloud column is seen to be in rapid rotation. It is not made up of an ascending mass of dust or water, but it is ascending air within which the cloud formation stretches downward. Those who do not actually see such a funnel-shaped cloud should call the storm a gust of wind or a violent wind, but not a tornado, and still less a cyclone. Winds that are violent enough to carry men and animals along horizontally, in spite of their own wills, may occur in connection with hurricanes and blizzards, but do not of themselves constitute tornadoes.

2. A mountainous locality is not apt to have a tornado. Severe thunderstorms of wind and cloudbursts of rain may occur, but a genuine tornado is almost unknown among high mountains. The reason for this is not because the mountains tend to break up the motion of the tornado, but rather because the mountains facilitate the formation of smaller and less violent windstorms, and because mountain air is cooler and drier, so that the atmosphere has no chance to pile up the great cumulus clouds, beneath which the tornado is formed.

3. A tornado often rises and descends alternately. The surface winds rush toward the low pressure within the funnel, and wherever the funnel cloud itself descends to the ground or near it there the great injury is done. Available statistics are not very clear as to whether a hill several hundred feet high can break up a tornado temporarily. Along the path of a tornado there are always some regions of greater and others of less destruction; in the latter the tornado funnel has simply risen above the ground, and such rises have no clear connection with hills and valleys. They probably depend almost entirely upon the mechanical actions going on overhead within the cloud, from which the tornado draws all its power.